

DISSERTATION ON

**THE MOTOR NEUROLOGICAL OUTCOME OF TRAUMATIC
CENTRAL CORD SYNDROME**

*Submitted in partial fulfillment of
requirements for
MS degree (Orthopaedics) Branch -II
of*

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certificate

This is to certify that this dissertation entitled “the motor neurological

*outcome of traumatic central cord syndrome ” submitted by **Dr.***

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examination in February-March 2006 is a bonafide record of work done by

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HISTORICAL REVIEW

Schneider(15) described an incomplete form of cervical spine injury in the year **1954** in which he stated that there was more involvement of the upper limb than the lower limbs with the affection of the bowel and bladder function . He studied the pattern of injury and the mechanism of injury

Albert Bosch, E.Shannon Stauffer and Vernon L. Nickel(1) in the year **1971** published the long term follow up of the patients who presented as various incomplete spinal injuries and concluded that conservative treatment gave an acceptable result

Jerald S. Brodkey(5) in the year **1980** published their study on the therapeutic aspects of CCS and showed that the compression was a major factor in the pathogenesis of the condition and the surgical decompression was useful

In the year **1984**, **Bikash Bose and Northrup(2)** in their study demonstrated that surgery has significant better outcome than conservative treatment in their retrospective study

Louis Penrod and Sunil Hegde(9) in the year **1990** published their paper and showed conclusively that age had an adverse effect on the neurological outcome

Quencer and Bunge(14) in the year **1992** published the paper on MRI and the pathological correlation in eleven patients and showed that the condition was mainly due to Cortico spinal tract involvement and there was no haematomyelia

Martin et al(10) in the year **1992** published their autopsy case report in a patient of central cord syndrome and showed that the pathological hall mark of this condition was the axonal disruption in the segmental level

Liyang Dai and Lianshun Jia(8) in the year **2000** published a paper which stated that in the non degenerated spine there was about 65% of disc bulge in cases of CCS and showed that there was a significantly good surgical outcome in such patients

Tzu-Yung Chen et al(17) in their retrospective study of 114 patients done in China published in the year 1996, showed that there was improvement in the condition of the patient with the surgical treatment

In a histopathological analysis on 5 of the human cervical spinal cord Jiminez and associates in the year **2000** demonstrated that the lateral corticospinal tract was the most commonly affected structure in the CCS

In a study published by **Martyn L Newey and Sen(11)** in the year **2000** on the long term outcome of central cord syndrome, 32 patients were followed up for a mean of 8.6 years and the effects of conservative treatment was analyzed in these patients and again the poorer outcome in the elderly was demonstrated

James Guest et al(4) in the year **2002** published papers where they analyzed the effects of early over late decompression in 50 patients and demonstrated that early decompression had a significantly better outcome than those treated by late decompression

REVIEW OF LITERATURE

ASIA definition of the traumatic central cord syndrome:

Dissociation in degree of motor weakness with lower limbs stronger than upper limbs and sacral sensory sparing

INTRODUCTION

Schneider in 1954 described the acute traumatic central cord syndrome which is characterized by disproportionate motor impairment in upper limb than lower limb and bladder dysfunction

MECHANISM OF INJURY

Schneider et al(15) proposed that ATCCS was as a result of hyperextension of the cervical spine and squeezing of spinal cord in AP plane by an inward bulging of ligamentum flavum in a narrowed spinal canal

PATHOPHYSIOLOGICAL CORRELATION

Schneider(15) proposed that CCS is due to bleeding into the central portion of the cord and resulting in hematomyelia with a cephalad and caudal extension.

Schneider in his classical review demonstrated that the vertebral artery could be injured or occluded at

- Site of entry at C5
- Bony canal osteophytes

- C1- IV foramen
- Occipital condyles

Schneider(15) cited that the traumatic central hematomyelia damages the most medially located “hand” corticospinal tract fibers in the lateral column quoting Foerster (1937) for the laminated arrangement of fibers

In studies by **Jimenez, A.Marcillus and D.Martin(6)** where extensive autopsy study and spinal cord analysis was done, there was compelling evidence for degeneration of corticospinal axonal tracts within the lateral columns. There was no difference in the motor neuronal count at a higher level of injury or at the site of injury. The site of CST wallerian degeneration was distal to the epicenter of injury.

Quencer et al(14) in their post mortem studies demonstrated damage to the axons in the white matter occupied by the lateral corticospinal tracts. High power microscopy demonstrated diffuse edema, early myelin breaking and axonal fragmentation. The explanation for an increased involvement of the hand grip more than the lower limb was probably due to the critical importance of the cortico spinal tracts in primates and its lesser influence on the locomotor activities of the lower limbs.

The hand dysfunction in ATCCS results from primary injury involving the large fibers of lateral CST and can occur in absence of motor

neuron loss supplying hand musculature indicating that the fibers subserving the hand fibers are the ones with the large diameter and they are more affected than the smaller corticospinal fibers.

The somatotopic arrangement of CST has never been demonstrated in spinal cord of human or higher mammals

The other explanations for deficit in CCS

- Injury to central grey matter of cervical enlargement at level of motor centers supplying hand
- Selective injury to uncrossed ventral CST
- Selective injury to forelimb CST collaterals to brain stem, central grey and dorsal column nucleus

In certain cases of severely injured ATCCS some degree of grey/ white matter destruction, possibly “pencil – shaped” centromedullary necrosis was noticed by *Jellinger k*.

MECHANISM OF INJURY

According to Schenieder et al the primary mechanism of injury is the hyperextension violence resulting in the PINCER like action of the ligamentum flavum on the spinal cord.

MODE OF VIOLENCE

STUDY	FALLS (%)	MOTOR VEHICLE ACCIDENT (%)	DIVING (%)	OTHERS (%)
Yoichira ishida et al	36.4	50	4.1	-
Louis Penrod et al	30	33	17	-
Liyang Dai et al	19	27	-	45
STUDY	FALLS (%)	MOTOR VEHICLE ACCIDENT (%)	DIVING (%)	OTHERS (%)
Tzu- yung Chen et al	2.6	93.8	-	-

CLINICAL FEATURES

The patient presents with a predominant involvement of the upper limb than the lower limb. The patient presents with involvement of bladder dysfunction and urinary retention. The lower extremity tend to recover motor power first, bladder function returns next and finally strength in the upper extremity reappears

The patients are examined based on the spinal motor charting and a serial motor examination is done to assess the neurological status of the patient.

The patients show progressive improvement in the motor neurological status with time.

PROGNOSIS

In the study of the natural history of the central cord syndrome by *Martyn Et al*(11)they found out that the younger patients had a better outcome than the elderly. In the category of younger patients (< 50 years) all were ambulant in comparison to the 69% of the patients in the age group of 50 -70

years and only 40% of the patients over the age group of 70 years were ambulant.

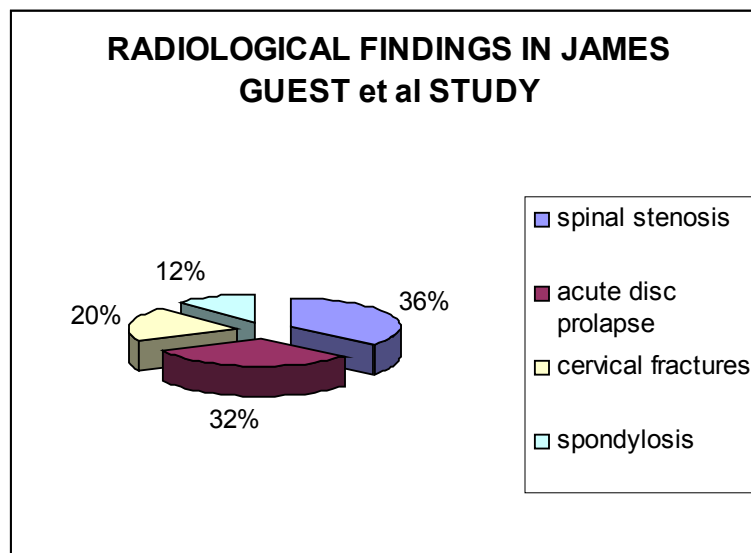
BLADDER FUNCTION

According to the study of **Martyn et al(11)** all patients who were younger than the 50 years age group recovered their bladder function while only 69% in the 50-70 year age recovered the function

RADIOLOGICAL FEATURES

Most of the studies on central cord syndrome include the analysis of the X rays, CT scan and the MRI scan.

In a retrospective study done by **James Guest et al(4)** the radiological investigations showed



MRI studies

In haemorrhagic lesions of the spinal cord the T 1 weighted spin echo would show increased signal due to metheamoglobin from 3 days or more of injury and in the T 2 weighted GRE sequence decreased signal from 8 hours to 2 days due to the presence of Oxyhaemoglobin. In the study of **Quencer et al(14)** there was high signal intensity in the T2 weighted image indicating that there was no haemorrhage into the cord and it was probably due to injury to the white matter tracts.

In the study done by **James guest et al(4)** spinal cord contusion was seen in 68% and cord compression was seen in 32%. A definite increase in the signal intensity in T 2 weighted images was associated with lower initial overall motor score.

White and Punjabi et al discussed the spinal instability initially in their seminal paper where they proposed the following factors that determine the spinal column integrity. The following pattern has been followed in the studies of **Bikash Bose et al(2)** regarding the spinal column integrity and it's bearing on the management of CCS.

Checklist for diagnosis of clinical instability

ELEMENT	POINT VALUE
---------	-------------

Anterior elements destroyed or unable to function	2
Posterior elements destroyed or unable to function	2
Relative sagittal plane translation > 3.5 mm	2
Relative sagittal plane rotation > 11 degree	2
Posterior stretch test	2
Cord injury	2
Root injury	1
Abnormal disc narrowing	
1	
Congenital spinal stenosis	1
Dangerous loading anticipated	1
5 = Clinical instability	

TREATMENT PROTOCOL

The goal of treatment of spinal cord injury is to preserve residual neurological function, avoid secondary injury and restore spinal alignment and stability.

Schneider et al(15) in their classical paper proposed that the condition of traumatic CCS should be treated conservatively and in some cases surgical treatment can be detrimental in determining the outcome of the patient. The surgical exercises were done mainly from the posterior approach and consisted of laminectomy, Pial incision .

But later studies by **Bikash Bose et al(2)** showed that the operated patients would have a significant better outcome than those treated conservatively. Their criterion for operation

was

- Failure to improve progressively after an initial period of improvement with persistence of compression
- Unacceptable instability groups

The outcome was analyzed by using the student t test

The neurological outcome according to the ASIA motor power scoring system as per the study of Bikash Bose et al

Mode of treatment	Admission	Discharge
Conservative	50.6 +/- 5.6	66.5+/- 5.4
Surgical	58.5+/- 6.9	79.9+/- 3.8

In another retrospective study done by **James Guest et al(4)** the surgical treatment was analyzed for 50 patients of central cord syndrome and the outcome of early versus late surgery was compared. The early cases were treated within 24 hours of trauma. In patients who had CCS secondary to acute disc herniation, cervical fractures or dislocations recovered a greater degree of motor function than those with spondylosis or stenosis if surgery was performed within the first 24 hours. Worse motor outcome was associated with patients who were more than 60 years of age and those who had a bladder dysfunction. They concluded that early surgery is safe and is more cost effective than late surgery for the treatment of traumatic CCS, which was associated with disc prolapse and

fractures.

In a retrospective study done by **Liyang Dai et al(8)** on 24 cases they analyzed the correlation of disc herniation with central cord injury and evaluated the role of interbody fusion after decompression. The patients showed improvement of motor power from 47.79 ± 19.66 to 86.46 ± 10.22 . The factors that affected the outcome was age. It was very negatively associated but there was no correlation between the amount of compression and the outcome. The disc herniation was noted most in the C5-C6 level majority of the patients had a cord compression of less than 1/3. Cervical disc herniation in their study was found to be far more common than previously thought 64.48. Their study excluded cases of cervical spondylosis.

In another retrospective study of 114 cases with acute or chronic TCCS by **Tzu-Yung Chen et al(17)** they analyzed the efficacy of surgical treatment in traumatic central cord syndrome. In their study they inferred that operation was recommended when there was either a failure to improve in strength for ADL or less than grade 3-muscle power 2 weeks from time of trauma. The result of their study indicated that rapid motor improvement was achieved in 28 surgical patients, but there was no statistically significant improvement in the outcome regarding the bladder function and lower limb motor recovery. The surprisingly good result in sensory and motor function improvement early after the surgery indicates that there is a vascular component in the pathogenesis of CCS.

In a study to analyze the factors in the prediction of recovery in patients with central cord syndrome with only upper limb impairment by **Yoichiro ishida et al(20)** they designed the prospective study for 22 patients upto 2 year follow up. All the patients

were treated non-surgically. The neurological assessment was done by ASIA motor and sensory charting. In their study the following results were found. The mean sagittal diameter of the spinal canal was 14.8 mm and 32% of patients had radiological evidence of developmental cervical canal stenosis and 9% had evidence of OPLL. 59% had cervical spondylosis. The best predictor for the neurological recovery of motor, light touch sensation and pin sensation was the absence of abnormal signal intensity in the spinal cord. The motor recovery occurred rapidly in the first 3 weeks and reached a plateau by 6 weeks and the severe initial neurological damage and old age had poorer recovery. The sensory recovery required more time. The cord edema was seen in 18%. None of the patients showed evidence of haemorrhage. The presence of cervical spondylosis, cervical canal stenosis and OPLL were negatively correlated and were associated with a poorer outcome than that of the fracture group. In majority of patients the initial ASIA score was 84.4 % +/- 1.7 and the percentage deficit improvement was 98.6% +/- 1.4%.

In a study by **Louis E. Penrod et al(9)** the age effect on prognosis for functional recovery in acute traumatic CCS was done. the etiological cause for the CCS varied in various age groups. 51 patients were studied and the following results were derived. 97% of the younger age group were independent ambulators and 41% of patients in the age group of > 50 years became independent ambulators. In the younger age group 83% had bladder recovery while 29 % of the older patients had bladder recovery. In the study of **Martyn et al(11)** all patients in the age group < 50 years had regained

bladder control while 69% showed recovery in the age group of 50-70 years.

FUNCTIONAL OUTCOME

In the study of **Penrod et al(9)** only one out of 30 patients was non ambulant while in the >50 years age group 10 out of 17 were non ambulant.

All in the younger age group were independent in the eating and the grooming activity while only 71% of the elderly had this status. In study of **Martyn et al(11)** the functional outcome was that the younger sub set of patients (<50 years) all had ambulatory status and in the 50-70 year age bracket 77% of the patients were ambulant.

MATERIALS AND METHODS

This is a study of 25 patients who presented to the Government General Hospital, Chennai with ATCCS, between June 2003 to August 2005.

INCLUSION CRITERION

Patients presenting as traumatic central cord syndrome

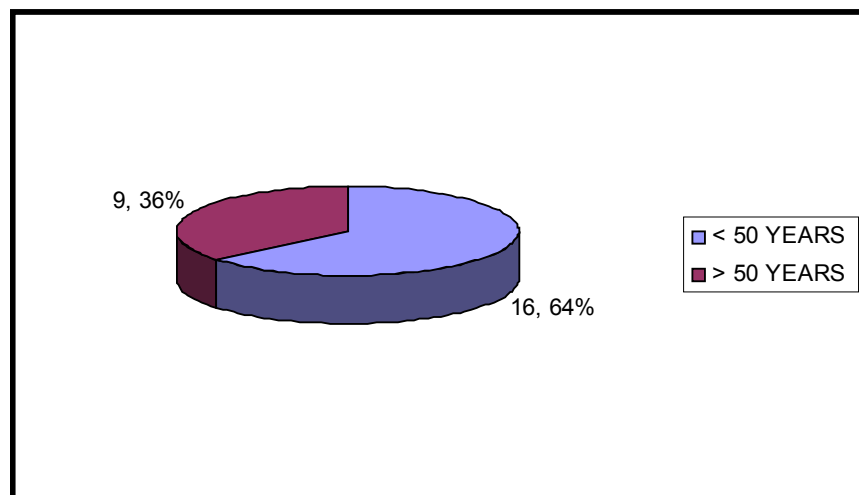
EXCLUSION CRITERION

Patients who presented in atypical manner and the recovery pattern follows that of the central cord syndrome.

PATIENTS LOST FOR FOLLOW-UP - 6

AGE INCIDENCE

The patient's age ranged from 18- 80 years



SEX INCIDENCE

RESULTS

The patients in our study were assessed by the following methods and the conclusions were drawn.

ASSESSMENT METHODOLOGY

The patients were assessed based on the American Spinal Injury Scoring System for the motor assessment of the patients

The neurological assessment in the institution was done on a fortnightly basis by a single person

The patients were assessed for the functional outcome by the FIM instrument devised by the University of Buffalo at the time of discharge and at follow- up

CLINICAL PARMETERS FOR ASSESSMENT

- 1) Motor power
- 2) The patient's sensory assessment was omitted because of the inconsistency in the sensory examination in the acute trauma setting.

RADIOLOGICAL ASSESSMENT OF THE SPINAL CANAL

The patients canal diameter was assessed radiologically using the X rays and CT scan. To remove the effect of the magnification the TURG-PAVLOV'S ratio was taken into the consideration and the assessment done. The magnification can be a serious problem in the radiological investigation so to eliminate that effect a new technique was devised where the magnification cancels itself in the ratio.

PAVLOV'S RATIO	-	<u>maximum AP diameter of the canal</u>
		Maximum AP diameter of the vertebral body

FUNCTIONAL OUTCOME OF THE PATIENT

The patient was assessed based on the Functional Independence Measure scoring system devised by the University of Buffalo.

It is an ordinal scale with 18 items in it and there are 6 levels of scoring in the system which ranges from 18- 126.

The areas that are evaluated in this methodology are-

1. Self-care
2. Sphincter control
3. Transfers
4. Locomotion
5. Communication
6. Social cognition

This method was chosen for its reliability and its interobserver conformity and its relevance in the assessment of the patient's ability in performing the Activities of Daily Living

Our patients were treated with recumbency during the course of our treatment so the initial assessment of the FIM was omitted and the assessment was performed during the discharge of the patient and during the follow-up.

STATISTICAL METHODS USED IN OUR STUDY

The computation of the change of the motor power was done using the formula:

Percentage Deficit improvement (PDI) =

$$\frac{\text{Final motor power} - \text{initial neurology}}{\text{Maximum score} - \text{initial neurology}} \times 100$$

1) The motor power changes were calculated using the student t test. Student t test is a test where the significance of difference between two means can be compared.

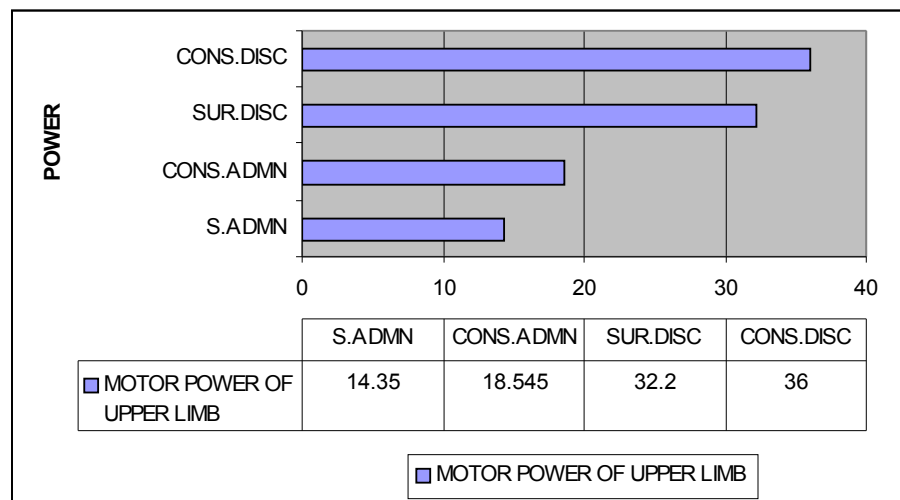
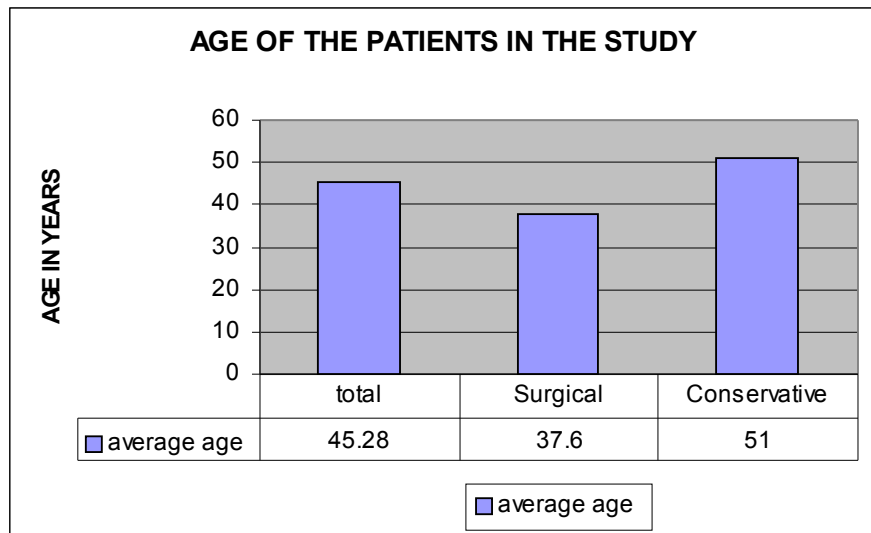
Logistics for using the student t test was that the data that was analyzed was quantitative in nature and the sample size was <30.

2) The correlation of the canal diameter and the neurological outcome was done by using the Pearson correlation co-efficient method.

Motor power improvement was calculated using the student t test and the following were compared

- **Comparison of the conservative and the surgical groups**
- **Improvement in the upper and the lower limbs individually**
- **The canal stenosis and the neurological outcome**
- **Comparison of the age and the neurological outcome**

BASIC STATISTICS OF THE STUDY



RELATION WITH TIME

	AVERAGE DURATION
Time of injury- time of admission interval	50.78 hours
Time of injury –time of surgery interval	43.66 days

FOLLOW-UP OF THE

PATIENT

Follow-up	Range (months)	Average (months)
Conservative	2-26	10.7
Surgical	6-14	9.2

TABLE SHOWING THE MOTOR IMPROVEMENT IN THE
CONSERVATIVE GROUP

	INITIAL POWER	FINAL POWER	PDI
RANGE	36-84	76-98	62.5-96.66
AVERAGE	54.4	88.2	73/. 813

TABLE SHOWING THE MOTOR IMPROVEMENT IN THE SURGICAL
GROUP

	INITIAL POWER	FINAL POWER	PDI
RANGE	20-85	60-100	23.07-100
AVERAGE	48.11	85.33	71.08

TABLE SHOWING THE MOTOR IMPROVEMENT OF THE LIMBS-
CONSERVATIVELY TREATED PATIENTS

	INITIAL POWER	FINAL POWER	PDI
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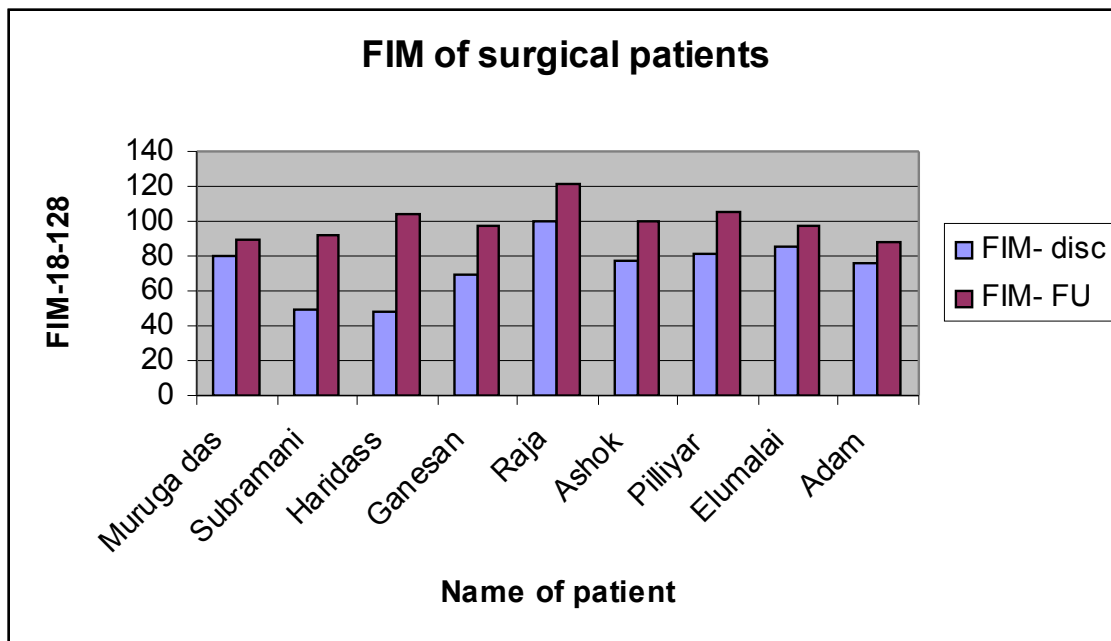
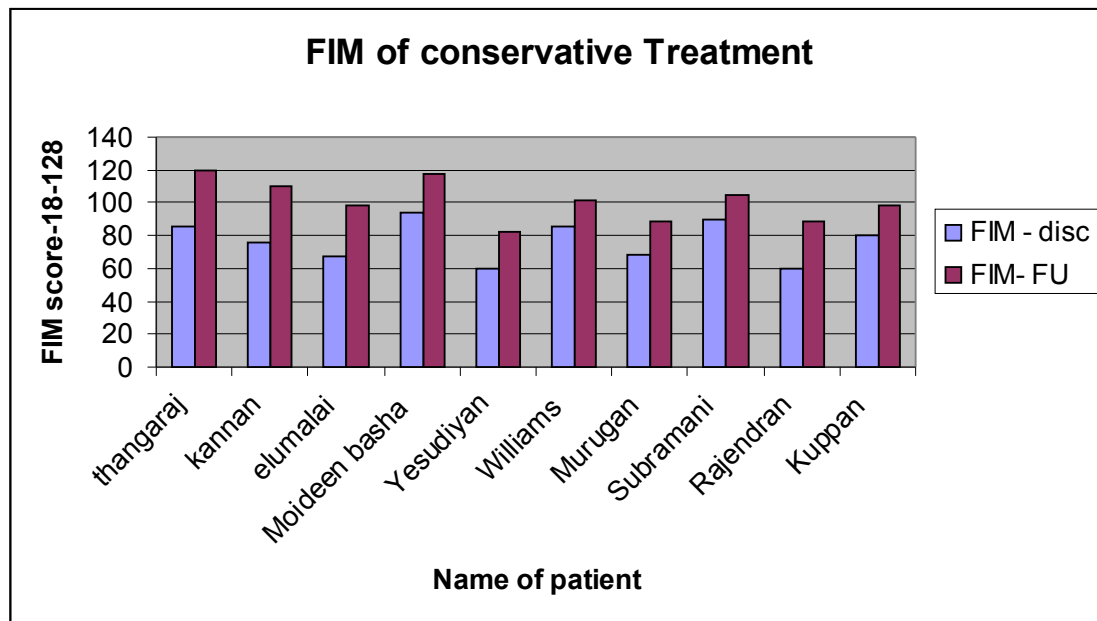
UPPER LIMB: RANGE AVERAGE	0-34 18.54	26-48 40.90	20-96 69.91
LOWER LIMB: RANGE AVERAGE	30-50 38.76	40-50 47.45	60-100 84.48

**TABLE SHOWING THE MOTOR IMPROVEMENT OF THE LIMBS –
SURGICALLY TREATED PATIENTS**

	INITIAL POWER	FINAL POWER	PDI
UPPER LIMB: RANGE AVERAGE	0-35 12	20-50 40.88	18.91-100 88.39
LOWER LIMB: RANGE AVERAGE	20-50 36.11	40-50 46	-20 - 100 62.37

FUNCTIONAL OUTCOME OF THE STUDY

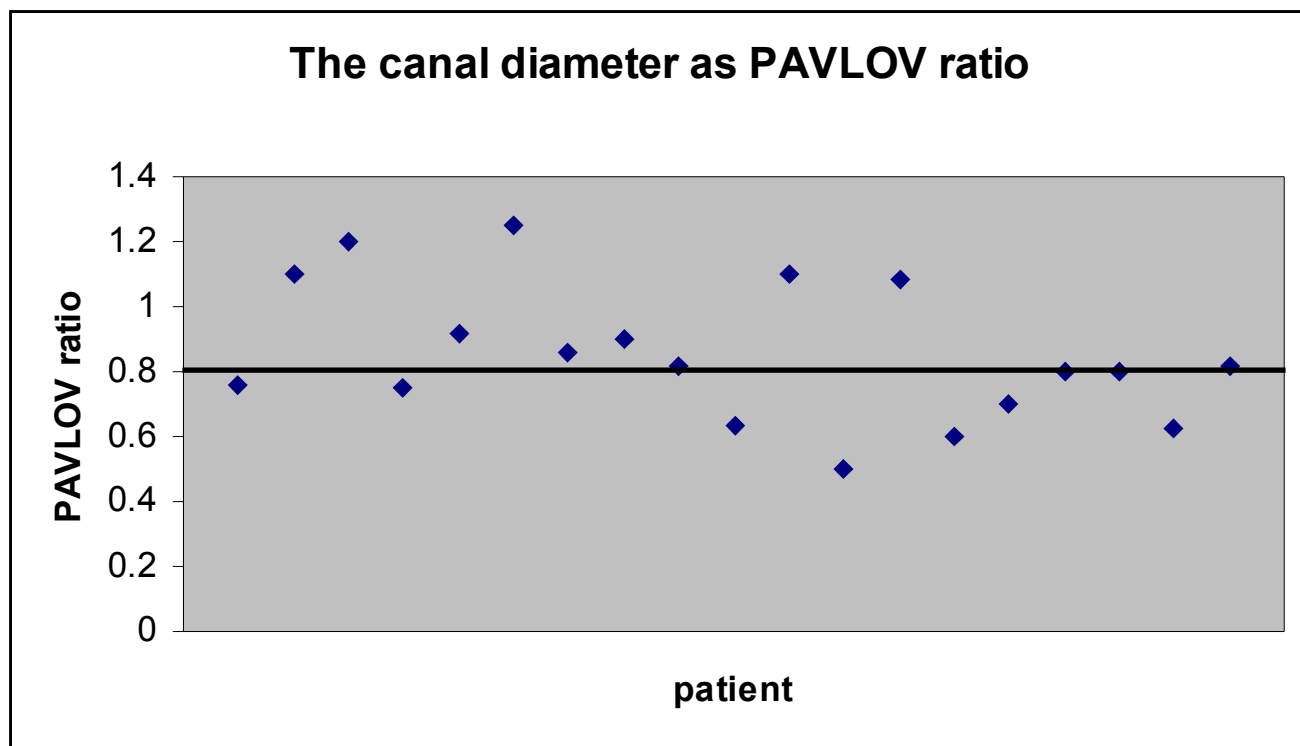
The functional independence measure in the conservative and the surgically treated patients was as follows all patients showed improvement at follow-up



Of seven patients who were more than 50 years 4 of them became community ambulators, two were ambulant for ADL while one patient needed aided ambulation. In the patients who were less than 50 years, 8 were community ambulators, 5 were ambulant for ADL. Three patients more than 50 years needed aid for their eating while four in the <50 years needed help in this activity.

MEASUREMENTS OF THE SPINAL CANAL

The measurement was done from the anterior border of the vertebral body to that of the posterior part for the measurement for the body and for the canal by measuring the diameter from the posterior body to that of the spinous process



COMPLICATIONS IN OUR TREATMENT

Complications	Number of patients
Pharyngocutaneous fistula	1
Post-operative neurological deterioration of the lower limb power	2
Post operative infection	2
Screw loosening	1
Pressure sore – occipital	2
Pressure sore- sacral	3

**DETAILS OF THE PATIENTS WHO WERE NOT INCLUDED IN THE
FINAL ANALYSIS OF THE DATA AND THE REASON**

Patient	Status
Perumal	C5-C6 subluxation patient treated conservatively and patient refused surgery and lost for follow-up
Parameshwari	No bony injury, LOFU
Allema Bee	No bony injury with degenerated spine, LOFU
Bala- subramaniam	Still under treatment
Patient	Status
Chellappan	Patient death due to reaction during CT myelogram
Gopi	C4 over C5 subluxation treated by lateral mass fixation, LOFU.

ANALYSIS OF THE OUTCOME WITH RESPECT TO AGE:

The patients were divided into two groups with the first group being patients who were <50 years and the second ≥ 50 years.

The following observations were made after analyzing the details with the student t test and it was found that age was a definite risk factor for the poor prognosis, since the neurological improvement was less in the patients who were more than 50 years of age.

The data that is used for the analysis as “X” is the percentage deficit improvement.

	ΣX	ΣX^2	SD	SE	dF	T ₁₇
< 50 years (12)	879.42	38760.04	23.42	0.475	19-2=17	2.5049
>50 years (7)	498.28	71112.74	24.61			

At probability of 0.05 the t value for '17 df' according to Gosset's table is **2.11** but in our study the value which has been obtained is **2.5049** which is significantly higher than the given value which proves that age is a definite adverse factor for the neurological outcome.

ANALYSIS OF THE OUTCOME WITH RESPECT TO THE CANAL DIAMETER

The data that is used for the analysis as "X" is the percentage deficit improvement.

	ΣX	ΣX^2	SD	SE	dF	T ₁₇
≤ 0.8 (9)	657.11	50646.47	18.26	11.128	17	0.9193
>0.8(10)	720.76	59254.8	28.49			

At the degree of freedom of 17 the value of t that is significant is 2.11 but the value in our study was 0.9193 where the patients were grouped into those with the canal diameter ≤ 0.8 and > 0.8 . This is not a significant finding since the 'r' value in the study is 0.485.

ANALYSIS OF THE OUTCOME WITH RESPECT TO THE SURGICAL VERSUS CONSERVATIVELY TREATED PATIENTS

The data that is used for the analysis as "X" is the percentage deficit improvement.

	ΣX	ΣX^2	SD	SE	dF	T ₁₇
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Conservative (10)	738.13	57772.6 7	19.117	11.105	17	0.875
Surgical (9)	639.79	52128.4 1	28.84			

With the 0.05 probability the t value should have been 2.11 or more for the above data to be statistically significant but the data we have obtained in the surgical versus the conservatively treated group shows that the apparent good result due to the surgery is within the biological variability.

The analysis of the correlation of the canal diameter as the determining factor for the neurological outcome we used the Pearson's correlation coefficient in this study.

	Torg-Pavlov ratio (X) average	Motor power (Y) Average	$x(X-\bar{X})^2$	$y(Y-\bar{Y})^2$	Σxy	r value
Conservative (10)	0.759	88.2	0.352	939.6	8.838	0.485
Surgical (9)	0.951	86.88	0.0382	1270.37	0.6317	0.090

The correlation values that were obtained for the conservative series was $t = 1.544$ and at that degree of freedom for ten patients with the P value being 0.05 is 2.31 and in the surgically treated patients with degree of freedom for nine patients the $t = 0.2390$ while the expected value within the two standard deviations is 2.37 so the values that are obtained in our study were due to the inherent biological variability rather than the play of the factor under the study.

BLADDER CONTROL IN OUR STUDY:

Most of the patients did not have bladder control at the initial review but by the final follow-up majority of the patients had regained the control of bladder. 7 out of 10 conservatively treated and 6 out of the 9 surgically treated patients had bladder control affected at admission. Three patients out of the 19 did not have bladder control at the final follow-up and one patient had developed a peri-urethral fistula and is now on supra pubic catheter. The two patients who have not regained bladder control are in the age group > 50 years. The patients regained bladder control at a mean of 4.2 months.

DISCUSSION

Traumatic central cord syndrome is a type of incomplete cervical spinal injury whose treatment methods are still evolving and there are controversies about the risk factors associated with the condition. Most of the studies done on central cord syndrome are retrospective and the outcome analysis is thus affected by factors beyond the control of the investigator. Our study is a prospective study of traumatic central cord syndrome. There are only a couple of studies designed prospectively for the study of this condition. The mean follow-up of our study is 9.95 months with the follow-up ranging from 2-26 months.

The average of patients in our study was 45.28 in which the surgical group had an average of 37.6 years and conservative had an average of 51 years. In the study of **Martyn et al(11)** the average age of the patients was 60.8 years. In the study of **Bikash Bose et al(2)** the average age of the patients was 41.6 years for the surgical group and 46.6 years for the conservative group. The younger age of the surgical group in our study indicates that the nature of violence in the surgically treated group was severe enough to cause instability and warrant surgery in comparison with the conservative group who had low energy violence.

The majority of our patients were male 92 %. In comparison, in the study of **Bikash Bose et al(2)** males constituted 71.4 % and in the study of **Penrod et**

al(9) males were 64.7 % while in the study of **Martyn** et al(11) the sex ratio was 81.25 % with a male preponderance. The predominance of males in our study indicates that the injury is sustained during outdoor activities.

The mean duration from the time of injury to admission in our study was 50.78 hours, which indicates that the patients were referred to our institution for tertiary care and this duration might have had an influence on the outcome of the study. The patients who were surgically treated were operated with a mean duration of 43.66 days from the time of injury. In the study of **Bikash Bose** et al(2) the patients were operated with 20 ± 4 days of admission.

The motor outcome in our study was as follows. In the conservatively treated group there was a mean improvement of 33.8 motor points while in the surgically treated group the 37.22 points. The mean PDI improvement in conservative group was 73.81 % while in the surgical group was 71.08%. The upper limb showed a mean improvement of 21.36 points in the conservative group and in the surgical group it was 27.88 %. The lower limbs showed a mean improvement of 8.69 points and the surgical group 9.89 points. Though the surgical group showed a marginally better result with respect to the PDI for the upper limbs this was not statistically significant ($t = 0.27$). This might be due to the fact that the sample size was small and there was also the problem of the post-operative neurological deficit of the lower limbs in two patients, which had an adverse effect on the outcome on the final result. This problem of postoperative neurological deterioration was not seen in other

published studies. In the study of **Bikash Bose et al(2)** there was a mean improvement of 20 points in the conservative group from $(50.6 \pm 5.6 - 66.5 \pm 5.4)$ and in the surgical group from 58.5 ± 6.9 to 79.9 ± 3.8 . In the long-term outcome study by **Martyn et al(11)** they found that in patients less than 50 years there was an average of 14 motor points improvement for the upper limb while for those in the age group of 50-70 years there was 20 motor points improvement from admission to discharge. For the lower limbs there was an average of 8 motor points improvement in both the above category. In the study of J. Guest et al there was a statistically significant improvement with early surgery. In the study of Pollard.MD there was an average improvement of 29 motor points.

RADIOLOGICALRELATES

In our study there were five patients who under went MRI studies and of whom four showed features suggestive of cord edema. This result is in accordance with the study of **R.M.Quencer et al(14)** where the MRI studies showed that in eleven patients none of them showed evidence of cord haemorrhage but only cord edema.

AGE CORRELATION

In the younger age group in our study there was an average of 73.28% of PDI with a standard deviation of 24.61 while in those older than 50 years there was 71.182 with the SD of 23.42. This yielded a statistically significant difference with the t value of 2.5049 with the p being 0.05. In the study of age effect on prognosis by **Louis. E. Penrod(9)** the mean upper limb motor score improved

by 22 motor points while for the lower limbs there was 33 motor points; in the older age group there was a mean improvement of 16 motor points and in the lower limbs there was 24 motor points. Thus there study showed better outcome in younger patients. In the study by **Liyang Dai et al**(8) there was a negative correlation ($p < 0.001$) with the recovery rate in the elderly

CANAL DIAMETER

In our study a Turg- Pavlov ratio of ≤ 0.8 was taken as the value for canal stenosis and it was calculated at the level of C5, if the level of C5 was involved in trauma then the value was calculated at one level below it. There were 12 patients who had a canal stenosis while there were 7 patients with a normal spinal canal. On applying the Pearson's correlation coefficient the "r" value was calculated as 0.485 indicating that there was no correlation. The sample size is small to comment about the statistical significance of this finding. A larger sample would be needed to analyze the true significance of this factor. In the study of Yamazaki et al the AP canal diameter was a significant finding in the recovery of the patient.

BLADDER FUNCTION

7 out of 10 conservatively treated and 6 out of the 9 surgically treated patients had bladder control affected at admission. Three patients out of the 19 did not have bladder control at the final follow-up and one patient had developed a peri-urethral fistula and is now on supra pubic catheter. The two patients who have not regained bladder control are in the age group > 50 years. The patients regained bladder control at a mean of 4.2 months. In the study of **Martyn et al**(11) all patients < 50 years regained bladder control while in those in the age group of 50-70 years showed 69% bladder control and none more than 70 years had bladder control.

FUNCTIONAL RECOVERY

Of seven patients who were more than 50 years 4 of them became community ambulators, two were ambulant for ADL while one patient needed aided

ambulation, In the patients who were less than 50 years 8 were community ambulators, 5 were ambulant for ADL. Three patients more than 50 years needed aid for their eating while four in the <50 years needed help in this activity. In the study of **Penrod et al(9)** only one out of 30 patients was non ambulant while in the >50 years age group 10 out of 17 were non ambulant. All in the younger age group were independent in the eating and the grooming activity while only 71% of the elderly had this status. As in other studies patients in our study showed poor functional outcome with age. Some poor result in the younger than 50 years age group was due to the fact that more number of surgical complications occurred in this group. In our study more number of younger age group patients underwent surgery.

CONCLUSION

- Traumatic central cord syndrome has a significant good motor improvement over time.
- Age has a statistically significant adverse effect on the motor neurological outcome
- Canal diameter has no correlation with the neurological outcome
- Surgical treatment showed better improvement in the upper limb recovery but was not statistically significant
- Age has an adverse effect on the bladder function and the patients functional recovery for the ADL

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GENERAL ABBREVIATIONS

ATCCS	-	Acute Traumatic Central Cord Syndrome
CST	-	Cortico-spinal tract
ASIA	-	American Spinal Injury Association
OPLL	-	Ossification of Posterior Longitudinal Ligament
AC Joint	-	Acromio-clavicular joint
ADL	-	Activities of Daily Living
FIM	-	Functional Independence Measure

KEYS TO THE MASTER CHART

RTA	-	Road Traffic Accident
TOI-TOA	-	Time Of Injury to Time Of Admission interval
TOI-TOO	-	Time Of Injury to Time Of Operation interval
U/L	-	Upper-Limb
L/L	-	Lower-Limb
PDI	-	Percentage Deficit Improvement
FU	-	Follow- up
FIM	-	Functional Independence Measure
LOFU	-	Lost For Follow-Up